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## ENGINE OPERATING METHOD AND APPARATUS

## TECHNICAL FIELD

[0001] This invention relates to engines and, more particularly, to a method of operation and apparatus for increasing emission control and performance of single camshaft and comparable engines.

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## BACKGROUND OF THE INVENTION

[0002] It is known in the art relating to engine emission control that valve event induced combustion residuals in the cylinders are a fundamental limitation on permissible intake/exhaust valve overlap for providing acceptable engine idle smoothness and stability. Many sophisticated methods have been employed by various manufacturers to overcome this limitation. These include intake valve event phasing, exhaust valve event phasing, and dual independent camshaft phasing.

[0003] Unfortunately these solutions are not readily applicable to single overhead camshaft (SOHC) or cam-in-block engines because the exhaust and intake cam lobes are on the same physical camshaft. A camshaft phaser, or cam phaser, controlling such a cam/valve train has only a very minor impact on trapped idle residuals, and generally increases residuals as the timing is advanced or retarded significantly from an optimum timing without variable timing capability, which worsens the idle quality situation.

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## SUMMARY OF THE INVENTION

[0004] The present invention provides a solution that employs cylinder deactivation (cutout) in operation of the engine at idle and at low loads. By cutting out cylinders, the load on the operating cylinders is increased. For example, cutting out one bank of cylinders of a V-6 engine doubles the load

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on the remaining three cylinders, increasing manifold pressure and reducing the trapped residuals.

[0005] With the idle cylinder load increased, the valve overlap may be significantly increased. This provides gains in wide open throttle (WOT) bmeep (torque) and road load emissions and fuel efficiency with all cylinders operating. The addition of dual equal camshaft phasing, wherein the intake and exhaust valve events are retarded and/or advanced simultaneously and equally, significantly enhances the benefits to road load and WOT bmeep.

[0006] With cylinder deactivation employed at idle and the resulting improvement in combustion stability, the engine camshaft designer is free to increase the valve overlap area to more fully optimize WOT torque and power, and road load fuel economy and emissions. With the idle constraint reduced significantly, the optimum overlap area/lobe center spacing can be accurately determined with extensive engine testing and analysis to provide an increased torque curve and reduced road load fuel consumption and emissions simultaneously.

[0007] These and other features and advantages of the invention will be more fully understood from the following description of certain specific embodiments of the invention taken together with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWING

[0008] The single figure of the drawing is a cross-sectional view of a cam-in-block engine having the front end cam timing elements offset to illustrate all features of the invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] Referring now to the drawing in detail, numeral 10 generally indicates an automotive V8 engine shown in cross-section and having a cam-in-block overhead valve train. Engine 10 includes a cylinder block 12

having left and right cylinder banks 14, 16 each including four cylinders. The banks are arranged at a ninety degree angle. The cylinders 18 carry pistons 20 which are reciprocated in the cylinders through connection by connecting rods 22 with a crankshaft 24. An oil pan 26 is mounted below the cylinder block 12 and is adapted to contain oil for delivery through an engine driven oil pump 28 to the various moving components of the engine.

5 [0010] As indicated in a displaced portion of the figure, the crankshaft 24 is connected at a front end, not shown, of the engine with a drive sprocket 30. A chain 32 connects the drive sprocket with a driven sprocket 34 mounting a cam phaser 36. The cam phaser connects with a camshaft 38 mounted within the cylinder block 12. The camshaft 38 includes a plurality of cam lobes 40 that are operative to actuate valve lifters 42, 44 which connect through push rods 46 and rocker arms 48 to actuate the exhaust and intake valves 50, 52, respectively, of the engine cylinders.

10 [0011] The rocker arms and valves are mounted in cylinder heads 54, 56 carried on the cylinder banks 14, 16, respectively, and closing the upper ends of the cylinders 18 of the respective banks.

[0012] An intake manifold 58 supplies intake air and fuel injectors 60 supply fuel to cylinder intake ports 62 which are controlled by the intake valves 52 to allow timed admission of the air and fuel mixture into the cylinders. Exhaust valves 50 are operated in like manner to control the discharge of combustion products from the cylinders through cylinder exhaust ports 64.

20 [0013] In accordance with the invention, selected engine cylinders, including at least half the engine cylinders, are provided with so called switching lifters 42, 44 for actuating the intake and the exhaust valves. The lifters of the other engine cylinders may be conventional hydraulic lifters or, if desired, could also utilize switching lifters as do the selected cylinders. The switching lifters when actuated operate to deactivate the valves of

25 30 selected cylinders so that operation of the cylinders is cut out completely and

the engine operates on the remaining cylinders. Fuel injection into the cylinders is also discontinued when the cylinders are cut out by actuation of the switching lifters. A solenoid control valve 66 may be provided to control the oil pressure supplied to the deactivation portion of the switching lifters to  
5 change their mode of operation between normal powered operation and non-powered cylinder cut out.

**[0014]** The use of cam phasers on one or both camshafts of a double overhead cam engine has been proposed for varying the timing of at least one of the camshafts in order to increase or decrease the valve opening  
10 overlap of the end of closing of the exhaust valve and the beginning of opening of the intake valve of the same cylinder. Variation of valve overlap can be effective for controlling so called internal exhaust recirculation or, in other words, retention of exhaust gases in the cylinder, in order to obtain better control of emissions such as NO<sub>x</sub>, over a wide range of engine  
15 operation.

**[0015]** However, this use of a cam phaser is not possible on an engine where all of the cams are on the same camshaft as is the case in the cam-in-block engine 10 described above. The valve overlap in such an engine is necessarily fixed by the positioning of the cams on the camshaft and cannot  
20 be changed by varying the timing of the camshaft. Thus, the camshaft timing in such engines is generally limited by the requirements of maintaining smooth and stable idle operation of the engine at the expense of higher performance when the valve overlap is increased and of increased emission control by the same process of increasing the valve overlap.

**[0016]** Also, switching lifters have been utilized for cutting out certain engine cylinders during road load operation at less than full throttle in order to maintain the remaining operating cylinders at a higher load level for greater efficiency of the overall engine operation as well as improved  
25 emission control. However, this does not alone change the situation with

respect to limitation of the amount of valve overlap allowed by the requirements of a smooth engine idle.

**[0017]** In the present invention, the characteristics of the switching lifters are combined with the application of a cam phaser to the camshaft of a cam-in-block or other comparable engine in order to provide a novel method of engine operation for improving both engine performance and emission control. In the operating method of the invention, idle and low load operation of the engine are conducted with up to one half of the cylinders of the engine cut out so that the engine is idled or operated at low loads on only one half of the cylinders operating at a substantially increased load level.

**[0018]** This allows the camshaft to be designed with increased valve overlap, which will still provide stable idle operation because the cylinders are operating at a higher load level where increased valve overlap does not cause instability. At the same time, idle efficiency is improved and emission control in the idle condition is also improved. The increase in the valve overlap also assists in controlling NO<sub>x</sub> emissions at intermediate loads and speeds and allows greatly improved engine performance under wide open throttle conditions. Further, the addition of the cam phaser 36 to control timing of the engine camshaft allows increased control of emissions at part load during cruising and other modes of vehicle operation at less than full throttle or near wide open throttle.

**[0019]** Accordingly, it has been shown that the operation of an engine having a camshaft with a fixed valve timing may be improved by the combination of switching lifters for operating the engine at idle and low loads combined with increasing the cam timing as permitted by operation on only part of the cylinders at idle. Finally, the addition of the cam phaser allows varying cam timing as desired in the intermediate load ranges where variation of the cam timing can be utilized to control emissions in a more effective manner.

**[0020]** While the invention has been described by reference to certain preferred embodiments, it should be understood that numerous changes could be made within the spirit and scope of the inventive concepts described. Accordingly, it is intended that the invention not be limited to the disclosed  
5 embodiments, but that it have the full scope permitted by the language of the following claims.